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INVESTIGATIONS CONCERNING THE SELF-FERTILITY OF THE GRAPE, 1900-1902.

- I. POTENCY OF THE POLLEN OF SELF-STERILE GRAPES.
- II. INFLUENCE ON SELF-FERTILITY OF GIRDLING OR BENDING THE CANES.

S. A. BEACH.

- III. A STUDY OF GRAPE POLLEN.

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N. O. BOOTH.



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INVESTIGATIONS CONCERNING THE SELF-
FERTILITY OF THE GRAPE, 1900-1902.

S. A. BEACH.

SUMMARY.

I. POTENCY OF POLLEN OF SELF-STERILE GRAPES.

In previous experiments varieties of grapes which are self-sterile or nearly so have shown about as little ability to fertilize other self-sterile sorts as they have for fertilizing themselves. In the tests here reported they have usually likewise failed to fertilize self-fertile varieties. Indications are seen, however, that the pollen in some instances is not altogether impotent but that its own pistils are less congenial than those of some other varieties. Further investigation is needed to learn whether or not this self-sterility arises because the pollen is deficient in amount, or is not well developed, or is uncongenial to its own variety.

II. INFLUENCE ON SELF-FERTILITY OF GIRDLING
OR BENDING THE FRUITING CANES BEFORE THE
BLOOMING SEASON.

Girdling or bending sharply the fruiting canes of imperfectly self-fertile or self-sterile grapes before their blossoms open in some cases has stimulated them to increased productiveness. In other cases it has not.

Further tests are needed to learn whether such practice may under any circumstances be profitably followed with any American varieties in commercial vineyards.

INTRODUCTION.

Many kinds of cultivated grapes have been found to be more or less self-sterile. They either utterly fail to fruit or produce imperfect clusters when the vines are planted by themselves; but they may fruit abundantly when grown near enough to other varieties to secure cross-pollination. This is demonstrated in previously reported investigations which are summarized in Bulletin No. 157.¹ From other experiments it appears that the degree of self-fertility of a variety is a very good indication of its efficiency in fertilizing self-sterile kinds of grapes. So far as they have been tried, the self-sterile kinds are usually no more capable of fertilizing other self-sterile kinds than they are of setting fruit of themselves, but when pollen of strongly self-fertile kinds has been used on the self-sterile grapes an abundance of perfect fruit has generally developed. In such cases it is evident that the lack of fertility cannot be attributed to imperfection of the pistils. If these were imperfect no fruit would develop from them under any circumstances. The experiments just referred to are fully set forth in Bulletin No. 169.² Observations made in 1892 and in various succeeding years show that self-sterile varieties do produce pollen.³ The question then arises: Is such pollen altogether impotent? Is it as incapable of causing the fertilization of self-fertile as it is of self-sterile grapes? The experiments reported on the following pages were undertaken to get more information on this subject. The work was carried on with the efficient help of Mr. Heinrich Hasselbring and Mr. O. M. Taylor in 1901. Mr. Taylor also assisted in the work of 1902. At the same time the influence on self-fertility of checking the flow of sap, either by girdling or by twisting and bending the cane between the trunk of the vine and the fruit buds, was investigated. The report of this work is given in Part II of this bulletin.

In addition to these experiments a study of grape pollen was carried on in the laboratory in 1902, by Professor N. O. Booth. The results will appear in Bulletin No. 224.

¹ Reprinted in Annual Report of this Station for 1898: 518-563.

² Reprinted in Annual Report of this Station for 1899: 361-397.

³ Notes on Self-Pollination of the Grape. Proc. A. A. A. S. 1892, *Gard. and For.*, 1892: 451-452. Annual Reports of this Station 1892: 597-606, and 1894: 642-643; also other unpublished observations.

I. POTENCY OF THE POLLEN OF SELF-STERILE GRAPES.

LOCATION OF EXPERIMENTS.

Most of the tests here reported were carried on in the vineyard of Mr. E. C. Gillett, Penn Yan, N. Y. It is a pleasure to acknowledge Mr. Gillett's uniform courtesy and cordial co-operation in this work. A few of the tests were made on vines in the Experiment Station vineyards.

METHODS OF WORK.

In all cases the vines selected for the tests were apparently in good productive condition. They were similarly treated so far as spraying to prevent the attacks of fungous diseases was concerned; they were also similarly pruned, trained and cultivated. The plan which was followed was to castrate certain self-fertile varieties before their blossoms opened, and then to apply to them the pollen taken from certain self-sterile or imperfectly self-fertile sorts. In order to prevent the access of other pollen than that desired, the clusters to be pollinated were covered with manilla paper bags¹ as soon as they were castrated, and thereafter kept thus covered except during the operation of cross-pollinating them. The clusters selected to supply the pollen for the experiment were likewise bagged before blooming to prevent admixture of foreign pollen. They were kept in these bags till used.

Castration.—The methods of operating in castrating the buds were varied according to the condition of the buds when the work was performed. When the operation is delayed till the buds are opening or about to open there is danger that some stigmas may accidentally become self-pollinated during the process of castration. It was, doubtless, under such conditions that the self-pollinations occurred which resulted in the development of the few fruits mentioned in the list of check castrations. See Table I. But if, on the other hand, the buds are castrated too early they may fail to develop further and die before fertilization is accomplished.

¹The bagging was done according to the method shown in Bulletin No. 157: 401; also in Annual Report of this Station for 1898: 521.

In some cases the cap and anthers were removed by means either of pliers or scalpel. This method is well adapted to meet the conditions for successful operation when buds are about to open. In most cases, however, the operation was performed at an earlier stage in the development of the bud, and the cap and anthers were removed by pinching them between thumb and finger. By this method the work could be done more rapidly than by the use of tools. If the bud can be operated on at the most favorable stage in its development, usually the cap, with anthers inclosed, may be readily pulled off with one movement of thumb and finger without either injuring the pistil or self-pollinating it. In doing this the end of the cap is pinched either between finger and thumb or between finger and thumb-nail. As a check upon this method of castration, many clusters after being thus operated upon were immediately inclosed in paper bags without being cross-pollinated, and were kept covered till the blooming season had passed. Any fruit which developed on these clusters must have resulted from accidental self-pollination during the operation of castrating the blossom buds. The following is a list of the check castrations referred to with a statement of the number of fruits produced.

TABLE I.—CHECK CASTRATIONS.

Name of vine.	Number of clusters castrated.	Number of fruits developed.	Average fruits per cluster.
<i>Gillett red seedling</i>	4	20	5.
Beacon.....	8	0 }	0.56
Beacon.....	1	5 }	
Catawba.....	1	0	0.
Concord.....	19	0 }	0.15
Concord.....	1	3 }	
Diamond.....	15	0 }	0.375
Diamond.....	1	6 }	
Hartford.....	1	0	0.
Niagara.....	13	0	0.
Pocklington.....	6	0	0.
Worden.....	12	0 }	0.5
Worden.....	4	8 }	
Total.....	86	42	-----

Taking all clusters into account, the average number of fruits produced per cluster was 0.49. Estimating the number of cas-

trated blossoms per cluster at 50, it appears that less than 1 per ct. of the castrated blossoms developed into fruit. The method of castrating the grape with thumb and finger, if used with care, is well adapted for an experiment like the one under consideration. In this case so many blossoms were included in the tests that the general results may be accepted as giving a reliable indication of the potency of the pollen tested. In considering the results of the experiments, the fact should not be lost sight of that nearly 1 per ct. of the check castrations developed fruit from accidental self-pollination.

After castration the clusters were immediately inclosed in paper bags, which were closed with a wired label. This covering was not removed again till the operation of cross-pollination was undertaken.

Pollination.—When the varieties which had been chosen to furnish the supply of pollen came into bloom the covered clusters were cut off and, without removing them from the bag, were taken to the castrated clusters which were to be cross-pollinated. The stigmatic surfaces of the latter were then touched with the open anthers of the former. The pollen-bearing cluster was also shaken against the castrated blossoms; finally, after being cross-pollinated thus, the cluster was usually covered with the bag which had contained the pollen-bearing cluster. After being closed with a wired label this bag was then shaken so that loose pollen, if it should contain any, might perchance alight upon some stigmatic surface.

In these experiments the operation of cross-pollination was performed but once for each cluster. Whenever at the time of this operation a considerable percentage of the stigmas appeared not to be in good receptive condition note was made of this fact. This sometimes occurred when the pollen-bearing blossoms opened later than those which were to be cross-pollinated from them. When the conditions were reversed, and the blooming season of the pollen-bearing cluster was in advance of that of the variety to be cross-pollinated, the process of cross-pollination was, nevertheless, performed as above described. It is known that grape pollen may retain its vitality for days.

Labeling.—On the label was written the particular number by which the cluster was designated in the experiment records, the name of the variety and the name of the pollen-bearing variety. The name of the mother plant was always written first, followed by x and the name of the variety with which it was cross-pollinated. Thus, "9471 Concord x Lindley" indicated a particular cluster of Concord, which, after being castrated, was cross-pollinated with Lindley pollen.

VARIETIES UNDER EXPERIMENT.

Self-sterile pollen¹ was tried upon the five strongly self-fertile varieties—Concord, Delaware, Diamond, Niagara and Worden—and also upon Vergennes, which is often less strongly self-fertile.² The list of varieties selected to furnish pollen for the tests is given below. In previous tests these varieties have proved very nearly or quite self-sterile. They are Black Eagle, Brighton, Eldorado, Herbert, Lindley, Merrimack and Salem. The results of applying the self-sterile pollen obtained from these varieties to the stigmas of castrated self-fertile kinds are summarized in table II. For better understanding of the tabulated results, the following facts relative to the degree of self-fertility of certain varieties should be noted.

In most cases Brighton clusters utterly fail to develop fruit except when cross-pollinated. In rare instances self-pollinated clusters have produced a little fruit. The fruit thus produced is generally small and seedless, as illustrated in Bulletin No. 157, pl. III, fig. 1, and in the Annual Report of the Station for 1898, pl. LI, fig. 1.

With one exception, all clusters of Lindley which we have tested for self-fertility have been completely self-sterile. The single exception, consisting of one cluster which bore four berries, falls within the limits of error in testing self-fertility. Lindley, therefore, may be called practically self-sterile, if not absolutely so.

¹ Throughout this discussion "self-sterile pollen" denotes pollen produced by self-sterile varieties; "imperfectly self-fertile pollen" and "self-fertile pollen" have corresponding significance.

² The standing of Vergennes as to self-fertility is given on pages 275 and 277.

Merrimack pollen was applied to some castrated blossoms of *Gillett red seedling*,¹ while other castrated blossoms of the same kind were not hand pollinated at all. In both cases some fruit was produced, and therefore it is not certain that the Merrimack pollen was potent. See table I and table II.

Vergennes must be classed among the imperfectly self-fertile varieties, but yet it is sufficiently self-fertile to sometimes produce marketable clusters when self-pollinated only. In many cases, however, its clusters of self-fertilized fruit are too loose and unsymmetrical to be marketable. The influence of the condition of the vine, location of the vineyard and character of the season on the development of the self-pollinated clusters is not well understood; but it has been observed that in the same vineyards in some seasons the self-pollinated Vergennes clusters have been better developed than in others; also in the same season better self-pollinated clusters have been obtained in one vineyard than in others.

In the table all varieties in the column headed "Variety cross-pollinated" were castrated, except in those cases where self-sterile kinds had pollen of the same varieties used upon them. The rank of the various varieties as to self-fertility is either explained in the notes just given or is indicated in the table, under "Remarks."

¹The *Gillett red seedling* is an unnamed seedling growing in Mr. Gillett's vineyard.

TABLE II.—RESULTS OF CROSS-POLLINATING SELF-FERTILE GRAPES WITH POLLEN OF EITHER SELF-STERILE OR IMPERFECTLY SELF-FERTILE VARIETIES.

Variety cross-pollinated.	Variety furnishing pollen.	Number of clusters cross-pollinated.	Number of pistils cross-pollinated.	Number of fruits developed.			Remarks.
				Normal size.	Small and seedless.	Total.	
Black Eagle ¹ ..	Black Eagle..	7	0	0	0	See page 278 and table III.
Bailey	Black Eagle..	.....	.....	.....	.....	.....
Delaware	Black Eagle..	5	227	0	0	0	
Brighton ¹	Brighton	10	0	0	0	Brighton is almost self-sterile.
Delaware	Brighton	5	134	0	0	0	
Niagara	Brighton	2	85	0	0	0	
Eldorado ¹	Eldorado	5	0	0	0	Brighton is almost self-sterile.
Brighton ²	Eldorado	5	.....	0	0	0
Delaware	Eldorado	4	153	0	0	0	
Herbert ¹	Herbert	11	0	0	0	Two Herbert clusters had shed the pollen before the Niagara was cross-pollinated; the other 3 clusters had freshly opened anthers. Each cluster developed a few berries, some small and seedless, others of normal size. Average for 5 clusters, 3.8.
Concord	Herbert	4	219	0	0	0	
Niagara	Herbert	5	213	0	0	0	
Vergennes ⁴ ...	Herbert	4	.....	12	17	29
Worden	Herbert	1	191	0	0	0	
	Herbert	4	19	0	19	Lindley is nearly or quite self-sterile.
Lindley ¹	Lindley	9	0	0	0	Two fruits on one cluster. Castration probably delayed too long, so that fruits may be due to action of Worden pollen. Compare with results of Worden x Herbert above; and with Worden castrated but not cross-pollinated in table I.
Concord	Lindley	5	251	0	0	0	
Niagara	Lindley	5	259	2	0	2	
Worden	Lindley	5	159	20	0	20	

¹Not self-fertile; pollen from other plants of same variety applied to uncastrated flowers as a check. ²Flowers not castrated. ³Average of normal berries. ⁴More or less imperfectly self-fertile.

TABLE II—Continued.

Variety cross-pollinated.	Variety furnishing pollen.	Number of clusters cross-pollinated	Number of pistils cross-pollinated.	Number of fruits developed.				Remarks.
				Normal size.	Small and seedless.	Total.	Average per cluster.	
Merimack ¹	Merimack....	9	0	0	0	0	One cluster bore 4 small berries each containing one seed. This seedling is to some degree self-fertile; rank not definitely determined. These fruits probably resulted from accidental self-pollination of <i>Gillett red</i> . See page 272. Three fruits on one cluster.
Concord	Merimack....	5	281	4	0	4	....
<i>Gillett red seedling</i> .	Merimack....	4	147	36	0	36	9	
Niagara.....	Merimack....	5	277	3	0	3	Five fruits on one cluster.
Warden	Merimack....	1	19	0	0	0	0	
Salem ¹	Salem	15	0	0	0	0	Fruits on one cluster.
Concord	Salem	4	240	5	0	5	....
Diamond	Salem	1	27	2	0	2	2	In 1901, 14 self-pollinated clusters developed clusters of fruit; 6 symmetrical and compact; 2 only moderately compact yet marketable; 6 too loose for market. In 1902, 4 self-pollinated clusters were tested, giving no marketable bunches. Fruit clusters about like last described in 1901.
Herbert ²	Salem	5	....	0	0	0	0
Niagara	Salem	5	328	2	0	2	In view of the following results with Diamond and Niagara these tests should be verified.
Vergennes ⁴	Vergennes ...	14 } 4 }						
Concord	Vergennes ...	1 } 1 }	25 42	0 4	0 0	0 4	0 } 4 }	Both pollen and pistils appeared to be further advanced than desirable when the cross-pollination was made.
Diamond.....	Vergennes ...	3	102	38	0	38	127	
Niagara	Vergennes ...	5	270	125	0	125	25	

¹Not self fertile; ²pollen from other plants of same variety applied to uncastrated flowers as a check.³Flowers not castrated.⁴Average of normal berries.

In addition to the tests above described a few others were made, using more careful methods to insure both perfect castration without either injury to the pistil or self-pollination of it, and also an abundant application of the pollen used in cross-pollination. On June 28 unopened buds of Black Eagle were covered with manilla bags to prevent the access of foreign pollen. On June 29 they had begun to open. The whole cluster, without being removed from the bag, was cut from the vine and taken to the laboratory, where the anthers were removed, put into a wide, short test tube and shaken till the bottom of the tube was well covered with pollen. A cluster of Bailey, in which the buds were nearly ready to open, was then selected. Part of the buds were cut out and the rest, 24 in number, were very carefully castrated by means of pliers and scalpel. Both the tools and the fingers were repeatedly dipped into strong alcohol during the operation, to prevent accidental self-pollination. Any bud in which any dehiscence of the anther appeared was at once discarded. After castration the cluster was pushed into the tube as far as the tube would contain it and the naked stigmas brushed against the sides and bottom, which were covered with the Black Eagle pollen. Additional pollen was then applied to each pistil by means of a camel's-hair brush. Finally the cluster was inclosed in a manilla paper bag to prevent the access of other pollen. In a corresponding way other crosses were made. The name of the parents and the number of pistils treated are shown in the following list:

TABLE III.—STRONGLY SELF-FERTILE VARIETIES CROSS-POLLINATED WITH VARIETIES NEARLY OR QUITE SELF-STERILE. SECOND METHOD.

Variety castrated and cross-pollinated.		Variety furnishing pollen.		Number of clusters cross-pollinated.	Number of pistils cross-pollinated.	Number of fruits developed.		
Name.	Class.	Name.	Class.			Normal size.	Small and seedless.	Total.
Hopkins.	Strongly self-fertile.	Ozark	Nearly self-sterile...	2	92	34	.....	34
Hopkins.	Strongly self-fertile.	Hexamer ...	Self-sterile	2	49	15	2	17
Bailey ...	Strongly self-fertile.	Black Eagle.	Self-sterile.	1	24	1	.....	1

The fruits which developed to normal size were supplied with a little less than the usual number of seeds. One hundred Hopkins fruits from clusters open to cross-pollination averaged 4.05 seeds per berry; those of Hopkins x Ozark averaged 3.01, and Hopkins x Hexamer 3.03 seeds per berry. The single fruit of Bailey x Black Eagle had 3 seeds.

In order that the results of the tests which are shown on the preceding pages may be compared with those obtained in using the pollen of self-sterile varieties upon other self-sterile varieties, the following table of Bulletin No. 169 is reprinted here. The data given in that bulletin are here arranged with reference to the ability of each variety to fertilize itself as compared with its ability to fertilize the various self-sterile sorts upon which it was tried.

Explanation of table.—The x between two names indicates that the variety following the x was used in pollinating the variety whose name appears before the x. Thus, Brighton x Aminia indicates that the Brighton clusters were pollinated with Aminia pollen in the manner described on page 335 of Bulletin No. 169. The rating is on the scale of 100 points, as there explained, a perfectly formed and perfectly filled cluster ranking 100. The average rating and the number of tested clusters upon which the average is based are also stated. The highest rating which any single cluster in the test received is also given.

“Self-pollinated” indicates that the tested clusters were simply kept covered in paper bags during the blooming season. Sometimes the self-pollination was performed by hand, pollen from another vine of the same kind being applied in the manner described in footnote 2, page 340, of Bulletin 169. Such tests are marked “hand-pollinated” in the table.

TABLE IV.—COMPARATIVE FRUITAGE WITH DIFFERENT VARIETIES OF GRAPE
TRIED AS FERTILIZERS FOR SELF-STERILE SORTS.

Varieties tested.	Clusters tested.	Highest rating.	Average rating.	Varieties tested.	Clusters tested.	Highest rating.	Average rating.
AMINIA as fertilizer :				Brighton x Catawba	5	100	80.0
self-pollinated	2	0	0.	Aminia x "	4	90	89.0
"	9	0	0.	Merrimack x "	3	95	91.7
"	6	0	0.	Herbert x "	2	100	100.
"	10	12	1.2	Wyoming x "	1	100	100.
Brighton x Aminia	7	2	0.3	COLUMBIAN IMPERIAL as			
Wyoming x "	4	8	2.	fertilizer :			
BLACK EAGLE as fertilizer :				self-pollinated	8	100	96.3
self-pollinated	2	0	0.	Hercules x Colum. Imp.	5	50	36.0
"	10	0	0.	CREVELING as fertilizer :			
Barry x Black Eagle	5	0	0.	self-pollinated	5	0	0.0
Eumelan x "	2	0	0.	"	5	0	0.0
BRIGHTON as fertilizer :				"	5	0	0.0
self-pollinated	9	0	0.	Brighton x Creveling	7	0	0.0
"	5	0	0.	EATON as fertilizer :			
"	27	0	0.	self-pollinated	10	0	0.0
"	9	0	0.	"	6	100	90.
"	28	4	0.2	Hercules x Eaton	5	70	36.0
"	25	10	0.4	ELDORADO as fertilizer :			
"	5	4	0.8	self-pollinated	5	0	0.0
"	10	15	2.1	"	10	0	0.0
"	5	10	6.0	"	23	0	0.0
Black Eagle x Brighton	4	0	0.0	"	4	0	0.0
Eldorado x "	5	0	0.0	Herbert x Eldorado	4	0	0.0
Herbert x "	1	0	0.0	Brighton x "	4	15	5.2
Salem x "	3	0	0.0	EUMELAN as fertilizer :			
Aminia x "	6	10	1.7	self-pollinated	10	0	0.0
Lindley x "	3	12	4.0	"	9	0	0.0
Merrimack x "	4	35	8.8	"	3	4	1.3
Wyoming x "	6	50	12.0	"	1	20	20.
Hercules	2	?	?	HERBERT as fertilizer :			
CATAWBA as fertilizer :				self-pollinated	2	0	0.
self-pollinated	12	3	3	"	5	0	0.
"	16	100	81.9	"	9	0	0.
"	22	90	85.0	Salem x Herbert	5	0	0.
"	37	100	89.9	Eldorado x "	5	0	0.
"	24	98	85.5	Brighton x "	4	75	28.0
"	17	95	86.1	HERCULES as fertilizer :			
Eldorado x Catawba	4	2	0.5	self-pollinated	4	0	0.0
Salem x "	1	4	4.0	"	10	0	0.0
Lindley x "	5	95	63.0	"	1	4	4
Brighton x Catawba	8	95	74.4	Barry x Hercules	5	0	0.0

¹ Hand-pollinated.² See Bulletin 169:349.³ The clusters were perfect or nearly so, but were not rated on the scale of 100 points.⁴ One good cluster well filled, but all fruits seedless.

TABLE IV.—(Concluded.)

Varieties tested.	Clusters tested.	Highest rating.	Average rating.	Varieties tested.	Clusters tested.	Highest rating.	Average rating.
JEFFERSON as fertilizer : self-pollinated	3		95.0	SALEM as fertilizer : self-pollinated	25	0	0.0
“	4	100	75.0	“	5	0	0.0
“	7	60	39.3	Lindley x Salem	5	0	0.0
Brighton x Jefferson	5	100	64.0	Herbert x “	4	0	0.0
LINDLEY as fertilizer : self-pollinated	10	0	0.0	Brighton x “	4	0	0.0
“	9	0	0.0	Eldorado x “	5	2	0.4
“	25	0	0.0	Merrimack x “	5	4	0.8
Eldorado x Lindley	25	40	1.6	STATION 125 as fertilizer : self-pollinated	10	100	100.0
Herbert x “	5	0	0.0	Brighton x Station 125	5	100	90.0
Salem x “	5	0	0.0	STATION 146 as fertilizer : Brighton x Station 146	4	60	21.3
Brighton x “	5	2	0.4	STATION 156 as fertilizer : Brighton x Station 156	4	100	69.3
Merrimack x “	5	10	2.0	VERGENNES as fertilizer : self-pollinated	10		
MERRIMACK as fertilizer : self-pollinated	4	98	32.0	“	22	90	44.5
“	2	0	0.0	“	5	40	24.0
“	10	0	0.0	“	8	90	77.5
“	23	0	0.0	“	9	95	45.6
Salem x Merrimack	3	0	0.0	Brighton x Vergennes	7	100	53.9
Lindley x “	4	0	0.0	WORDEN as fertilizer : self-pollinated	10		
Herbert x “	3	0	0.0	“	9	100	100.
Brighton x “	5	0	0.0	“	23	100	96.5
NECTAR as fertilizer : self-pollinated	4	100	25.	“	20	100	94.5
“	9	4		“	5	90	84.0
Brighton x Nectar	2	100	0.9	“	6	100	95.8
NIAGARA as fertilizer : self-pollinated	5	75	90.0	“	24	100	93.7
“	10	100	40.0	“	20	100	96.9
“	23	100	75.7	Black Eagle x Worden	1	0	0.0
“	12	100	65.8	Eldorado x “	5	95	65.0
“	16	100	95.1	Lindley x “	5	100	70.0
“	20	100	93.3	Brighton x “	4	100	76.0
Aminia x Niagara	1	80		“	8	85	77.0
Brighton x “	5	100	52.5	Aminia x “	2	88	88.0
“ x “	9	88	85.7	Salem x “	5	100	89.0
Eldorado x “	5	100	76.	Merrimack x “	4	100	97.0
Lindley x “	5	95	77.0	Herbert x “	5	100	97.0
Merrimack x “	4	100	96.3	WYOMING as fertilizer : self-pollinated	10	0	0.0
Salem x “	5	100	98.0	“	4	4	1.0
Herbert x “	4	100	98.8	“	13	5	5
ROCHESTER as fertilizer : self-pollinated	10	100	100.	“	6	90	21.6
“	1	100	100.	Brighton x Wyoming	6	2	0.3
Brighton x Rochester	5	100	72.0	Aminia x “	5	20	4.0
SALEM as fertilizer : self-pollinated	10	0	0.0				

⁵ But one cluster produced fruit and that was gathered by grape pickers before it had been rated. Its rating was somewhere between 80 and 100, making the average between 6.1 and 7.7.

The results set forth in table II show that the pollen of the self-sterile varieties therein named is either deficient in amount or lacking in potency, or both. Table IV bears similar testimony on this point. The results given in table III show that some varieties which are nearly or quite self-sterile may to some extent fertilize certain other varieties. Occasional indications of this fact are also seen in tables II and IV. The questions, however, are still not satisfactorily answered as to whether the self-sterility under investigation arises because the pollen is uncongenial to its own pistil, or because it is deficient in amount, or because it is nearly or quite impotent either upon its own or upon other pistils. The last-named condition seems to hold with Black Eagle pollen, because, as shown in table III, even when it is supplied in abundance it fails to effect the fertilization of the pistil to which it is applied. The one fruit which developed when Black Eagle pollen was tried upon Bailey easily falls within the limits of error for such an operation, and cannot be considered as proof that the fertilization was in fact effected by the Black Eagle pollen. But in the cases where Ozark and Hexamer were tried upon Hopkins, as well as in instances which might be selected from the tests listed in tables II and IV, it appears that some varieties which, so far as tested, have proved self-sterile are to some extent capable of fertilizing other varieties. This is an indication that their pollen finds its own pistils less congenial than those of certain other varieties. It is hoped that further investigation of these questions may be made.

II. INFLUENCE ON SELF-FERTILITY OF GIRDLING OR BENDING THE FRUITING CANES.

In making the tests reported in Bulletin No. 169, to determine whether some varieties of grapes are better than others for fertilizing self-sterile kinds, two instances were observed in which self-fertility seemed to be increased on canes which had been bent so much as to obstruct the flow of sap. These varieties were normally nearly self-sterile. In tying the vines upon the trellis some fruiting canes had been bent so sharply that the transfer of elaborated food from the part beyond the bend was

necessarily checked. It was noticed that a little fruit developed on self-pollinated clusters borne on the distal part of such canes, while none or almost none was borne by corresponding clusters, either on other parts of the same canes or on other canes on the same vine. These observations suggested the question whether in cases of imperfect self-fertility the fruitfulness might not be increased by treating the fruiting canes in some way to increase the supply of elaborated food available to the developing essential organs of the blossoms. In order to gain information on this subject, some experiments were conducted in 1901 and 1902, in which the transfer of elaborated food from the fruiting cane to the supporting branch or vine was checked either by girdling the cane just beyond its first node or by bending or twisting it upon the trellis. This was done after the leaves began to appear but before the blossoms opened.

It is hoped that other tests may be made in which the operation of girdling or bending may be performed before the buds break, but this has not yet been done. After this work was started it was learned that ringing Zante grape vines is practised by the Greeks to promote setting of fruit, uniformity of bunch and increased size of berry¹. A narrow ring of bark $\frac{1}{8}$ " to $\frac{1}{4}$ " wide is taken from the trunk when the fruit is setting. In a short time the bark grows over the incision. In our own work a similar plan was followed so far as the ringing of the cane is concerned. About three weeks before the blossoms opened some fruiting canes of certain varieties chosen for the experiment were girdled by removing a ring of bark $\frac{1}{4}$ " to $\frac{1}{8}$ " wide between the first and second nodes. At the same time certain other canes on corresponding vines of the same varieties were either tied so as to lie horizontally upon the trellis wire for about one-fourth of their length, then bend sharply and follow the next wire in the opposite direction, or were twisted at about one-fourth their length by being wound twice around the wire as tightly as possible without breaking them. Ten days later the clusters had developed enough so that the work of covering them with manilla paper bags was done. The blossoms had not yet begun

¹Garden and Field (Australia), cited in *Pac. Coast Fruit World*, May 24, 1901.

to open at that time. At a suitable time when the blossoms were opening the clusters which were to be tested for self-fertility were cross-pollinated according to the method described on p. 273, or once, at least, during the blooming season were shaken up thoroughly, without opening the bags containing them, for the purpose of mixing the pollen among the blossoms of the clusters. Where the former method was followed the clusters chosen to supply the pollen were, in all cases, produced on corresponding bent or girdled canes of the same variety, and often were borne on the same vine as the cross-pollinated clusters. They had been likewise inclosed in bags before blooming to prevent admixture of foreign pollen. Clusters thus treated will be hereafter referred to as "cross-pollinated," which signifies only that they were supplied with pollen from another cluster, always of the same variety and produced under corresponding conditions. Clusters which were shaken in the bag containing them, but which were not treated with pollen from another cluster, will be referred to as "close-pollinated," by this term meaning that no other pollen was supplied to them but that borne in the same cluster.

The wound made in girdling the cane usually healed readily, but occasionally it did not. An extreme case of failure to heal is illustrated in pl. I, fig. 1.

At the close of the season the fruit clusters were rated on the basis of 100 points for a perfectly filled cluster. This rating was not based upon the size of the fruit as compared with normal specimens, but separate notes were made as to size of fruit, number of seeds, if any, and other features of interest. The results with each variety will now be presented.

BRIGHTON.

Brighton is usually self-sterile, but occasionally is slightly self-fertile.

On a girdled Brighton cane 5 clusters were cross-pollinated with pollen from other clusters on the same cane. They rated 60, 50, 60, 0, 0 respectively. Most of the fruits were below normal size and seedless. Some had abortive seeds and correlated with them an increase in size over the seedless fruits.

Occasionally a berry was found of normal size and with normal sized seeds. Only one seed in all the lot had a well-developed endosperm. Total number of berries, 49. Number of abortive seeds, 23. Fig. 2, pl. I, shows one of these clusters.

On another girdled cane eight clusters were close-pollinated. These rated 90, 50, 0, 65, 40, 0, 0. All fruits were seedless except one, which had three abortive seeds. Total berries, 70. Fig. 3, pl. I, shows one of these clusters.

On a bent cane five clusters were cross-pollinated with pollen from other clusters on the same cane. No fruit set.

On a bent cane nine clusters were close-pollinated. No fruit set.

On a normal cane 10 clusters were close-pollinated. No fruit set.

CONCORD.

Concord is strongly self-fertile.

On a girdled cane five clusters were cross-pollinated with pollen from other clusters on the same cane. They rated 98, 90, 93, 91, 78. Fruit normal in size. Average seeds per berry, 1.42.

On bent canes 10 clusters were cross-pollinated with pollen from other clusters on the same canes. These rated 88, 93, 92, 95, 93, 90, 75, 88, 75, 75. Average seeds per berry, 1.90. Fruit normal in size.

On a normal cane 5 clusters were cross-pollinated with pollen from other clusters on the same cane. These rated 80, 90, 98, 90, 88. Average seeds per berry, 1.72. Fruits of normal size.

DELAWARE.

Delaware is strongly self-fertile.

On a girdled cane two clusters were cross-pollinated with pollen from other clusters on the same cane. These each rated 100. The fruits were of normal size. Average seeds per berry, 1.28.

On a normal cane five clusters were cross-pollinated with pollen from other clusters on the same cane. These rated 100, 92, 100, 100, 100. Number of fruits and seeds in one cluster was not recorded. The other four clusters averaged 1.31 seeds per berry.

ELDORADO.

In previous tests Eldorado has always been found self-sterile.

On a girdled cane five clusters were cross-pollinated with pollen from other clusters on the same cane. They rated 6, 0, 0, 0, 12. Total berries, 9. These varied from less than normal to very small in size. They produced only three seeds and these were abortive.

On a bent cane five clusters were cross-pollinated with pollen from other clusters on the same cane. No fruit formed.

On a normal cane five clusters were cross-pollinated with pollen from other clusters on the same cane. No fruit formed.

HERBERT.

In all tests Herbert has proved completely self-sterile.

On a broken cane six clusters, on a girdled cane six clusters, on a bent cane five clusters and on a normal cane six clusters were cross-pollinated with pollen from other clusters on the same respective canes. No fruit set in any case.

NIAGARA.

Niagara is strongly self-fertile.

On a bent Niagara cane six clusters were close-pollinated. These rated 95, 85, 98, 95, 97, 90. Average seeds per berry, 1.89. Fruit of normal size.

On a normal cane 10 clusters were close-pollinated. These rated 75, 90, 78, 92, 98, 92, 78, 93, 90, 90. Fruits were of normal size. Average seeds per berry, 2.17.

SALEM.

In all tests Salem has proved self-sterile.

On a girdled cane 10 clusters, and on bent canes 10 clusters, were close-pollinated. No fruit set.

VERGENNES, IN 1901.

This is classed among the imperfectly self-fertile varieties. When self-pollinated only it sometimes produces marketable clusters, but in many cases the clusters under such conditions are too unsymmetrical and too imperfectly filled to be marketable.

On a girdled cane 10 clusters were close-pollinated. One failed to develop further; possibly it was accidentally broken during the treatment. The other nine rated respectively 100, 60, 100, 88, 100, 100, 100, 98, 80. Fruit normal in size. Seeds averaged 1.84 per berry.

On a bent cane 10 clusters were close-pollinated. They rated 100, 60, 100, 88, 98, 90, 82, 88, 95, 85. Fruit normal in size. Seeds averaged 2.66 per berry.

On a normal cane 10 clusters were close-pollinated. They averaged 80, 96, 75, 95, 80, 80, 90, 88, 88, 100. Fruit normal in size. Seeds averaged 2.38 per berry.

The following season (1902) the tests with Empire State and Vergennes were repeated. The Empire State vine, which was girdled in 1901, proved to be unhealthy, and so the results were not reported.

VERGENNES, IN 1902.

On girdled canes five clusters were cross-pollinated with pollen from other clusters on the same canes. The girdle did not heal over. The fruit was more backward in ripening and smaller than normal Vergennes. The clusters rated respectively 45, 78, 88, 70, 50. Number of seeds was not determined.

On bent canes five clusters were cross-pollinated with pollen from other clusters from the same canes; 6 other clusters on these canes were not bagged, but were left open to cross-pollination. Taking these into account, the clusters on the bent canes were, on the whole, better developed and better filled than those on the same vine which were borne on unbent canes. The clusters rated respectively as stated below:

On bent canes bagged clusters rated 60, 50, 50, 62, 75.

On bent canes unbagged clusters rated 100, 96, 97, 20, 95, 45.

On normal canes unbagged clusters rated 8, 70, 65, 75, 95, 38, 50, 85, 8, 15, 90, 75, 90, 50, 55, 80, 88, 35, 60, 35, 35, 55, 15, 12, 12, 18, 85, 25.

On a normal cane four clusters were cross-pollinated with pollen from other clusters on the same cane. These rated 75, 75, 65, 70.

In these tests the best results were obtained from uncovered clusters on bent canes. The covered clusters averaged somewhat better on the normal than on either the girdled or the bent canes.

EMPIRE STATE, IN 1902.

In previous tests Empire State has proved rather strongly self-fertile.

On girdled canes five clusters were cross-pollinated with pollen from other clusters on the same canes. They rated 100, 100, 100, 88. Fruit normal in size.

On bent canes five clusters were cross-pollinated with pollen from other clusters on the same canes. They rated 100, 100, 100, 90, 100.

On normal canes five clusters were cross-pollinated with pollen from other clusters on the same canes. They rated 100, 100, 100, 98, 100.

HERCULES, IN 1901.

In 1901 a Hercules vine trained to the four-arm Kniffen system was treated by having the lower north and upper south arms girdled. The upper north and lower south arms were left untreated. The clusters were all left open to cross-pollination. Hercules is self-sterile, but this vine usually bears fairly well because it stands in a mixed vineyard. The total number of clusters which developed fruit was 29 on the treated and 16 on the untreated canes. The weight of the fruit was 7.6 lbs on the treated and 4.6 on the untreated canes. In this case, as in the case where Vergennes was girdled and left open to cross-pollination, there is an apparent advantage from such treatment.

The results of the above-described tests are tabulated below.

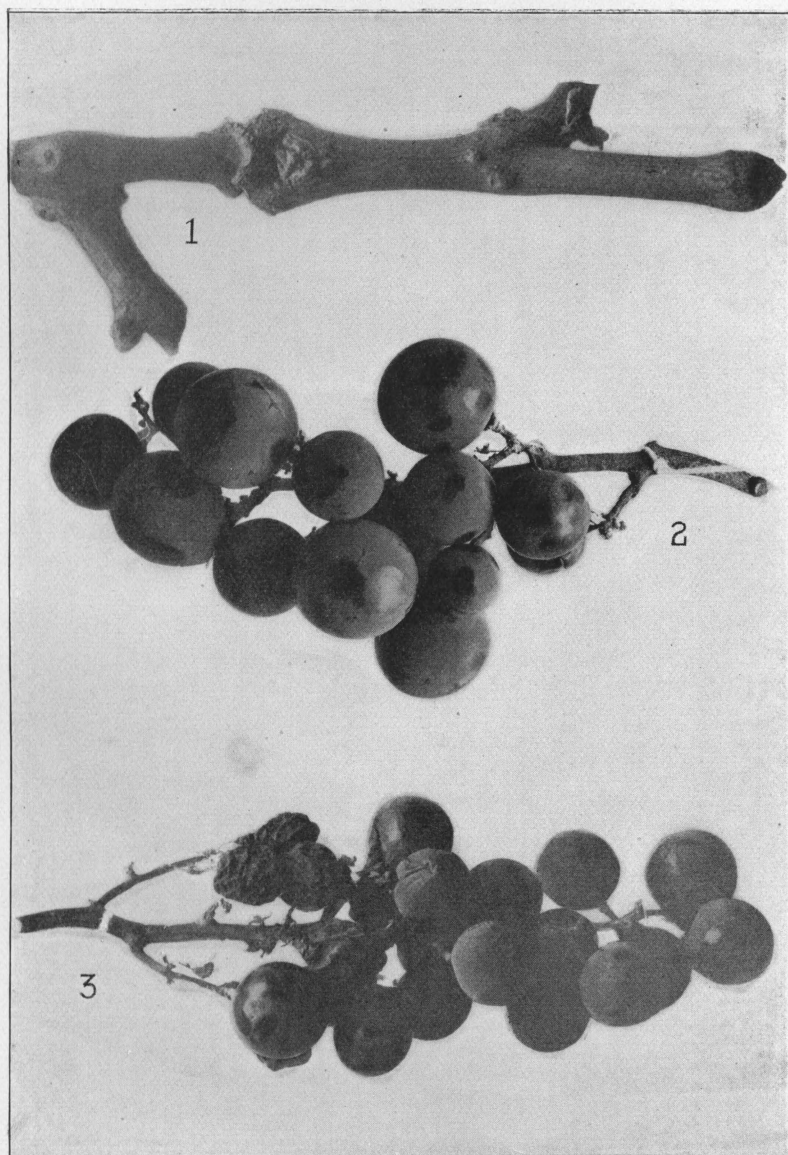


PLATE I.—EFFECT OF GIRDLING ON CANE AND FRUIT.

FIG. 1. FAILURE OF GIRDLE TO HEAL : AN EXTREME CASE.

FIGS. 2 and 3. BRIGHTON CLUSTERS ON GIRDLED CANES; EACH CLUSTER CROSS-POLLINATED WITH POLLEN FROM ANOTHER CLUSTER ON SAME CANE. BRIGHTON, SELF-POLLINATED, RARELY SETS FRUIT.

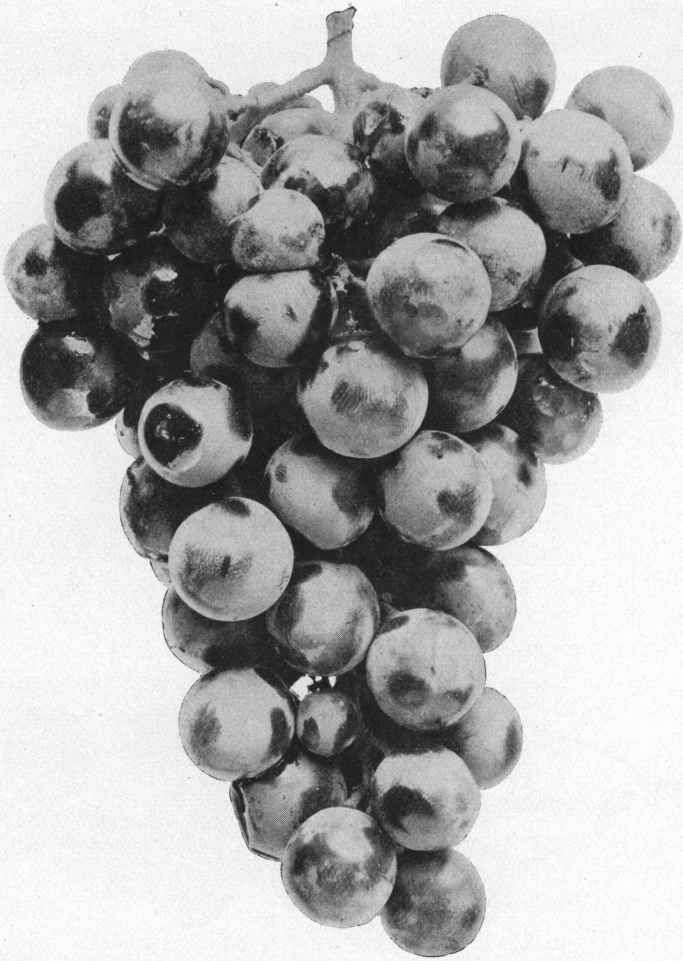


PLATE II.—BRIGHTON BORNE ON NORMAL CANE: POLLINATED WITH
STATION NO. 5—A STRONGLY SELF-FERTILE VARIETY.

TABLE V.—RESULTS OF GIRDLING OR BENDING THE CANES BEFORE THE BLOSSOMS OPEN.

Name	Clusters tested.	Kind of cane.	Character of fruit.	Average rating. ¹		Average seeds for fruit. ³
				Clusters bagged and self-pollinated. ²	Clusters not bagged. Open to cross-pollination.	
Brighton	5	girdled	mostly small and seedless	34	.....	.02
"	8	"	mostly small and seedless	535	.....	0
"	5	bent	none	0	.....	.....
"	9	"	"	50	.....	.....
"	10	normal	"	50	.....	.....
Eldorado	5	girdled	mostly small and seedless	3.6	.....	0
"	5	bent	none	0	.....	.....
"	5	normal	"	0	.....	.....
Herbert	6	broken in bending	"	0	.....	.....
"	6	girdled	"	0	.....	.....
"	5	bent	"	0	.....	.....
"	6	normal	"	0	.....	.....
Salem	10	girdled	"	50	.....	.....
"	10	bent	"	50	.....	.....
Concord	5	girdled	normal	90	.....	1.42
"	10	bent	"	86.4	.....	1.90
"	5	normal	"	89.2	.....	1.72
Delaware	2	girdled	"	100	.....	1.28
"	5	normal	"	98.4	.....	1.31
Empire State	5	girdled	"	97.6	.....	.....
"	5	bent	"	98	.....	.....
"	5	normal	"	99.6	.....	.....
Niagara	6	bent	"	593.7	.....	1.89
"	10	normal	"	587.6	.....	2.17
Vergennes 1901	10	girdled	"	591.84	.....	1.84
"	10	bent	"	588.6	.....	2.66
"	10	normal	"	587.2	.....	2.38
" 1902	5	girdled	"	66.2	.....	.....
"	5	bent	"	59.4	.....	.....
"	6	"	"	.....	75.5	.....
"	.....	normal	"	71.3	.....	.....
"	28	"	"	.....	52.6	.....
Hercules	.....	.....	.....	.....	6	.....

¹ The clusters were rated on the basis of 100 points for a perfectly filled cluster.² For full significance of this term see p. 284. Unless otherwise indicated these averages are for cross pollinated clusters.³ Seeds apparently abortive not included.⁴ Possibly this rating should be 82.6. See page 287.⁵ Clusters close pollinated. See note 2.⁶ The record of results with Hercules favored the girdling operation and leaving the clusters open to cross-pollination. See page 288.

From the results shown with Hercules and with those Vergennes clusters on a bent cane which were left open to cross-pollination it appears that the treatment stimulated to greater productiveness. Some evidence of such stimulation is also found in the cases of Brighton and Eldorado. Sample clusters of the former are shown in figs. 2 and 3, pl. I. For comparison with them a cluster of Brighton hand-pollinated with a pollen of a self-fertile sort is shown in pl. III. The treatment of the self-sterile Herbert and Salem failed to cause them to fruit.

The self-fertile varieties Concord, Delaware, Empire State and Niagara have generally a higher average rating on girdled than on untreated canes, but the advantage of the treatment, if any, is not striking.

If the girdling can be used on such nearly self-sterile varieties as Brighton and Eldorado, or such imperfectly self-fertile kinds as Vergennes, when these varieties stand in proximity to strongly self-fertile kinds and are exposed to cross-pollination from them throughout the blooming season, it may be that their productiveness may be thus profitably increased. Further investigations should be made on this point, as well as a comparative study of early and late girdling.

BULLETIN No. 224.

DECEMBER, 1902.

New York Agricultural Experiment Station.

GENEVA, N. Y.

INVESTIGATIONS CONCERNING THE SELF-
FERTILITY OF THE GRAPE, 1900-1902.

III. A STUDY OF GRAPE POLLEN.

N. O. BOOTH.



PUBLISHED BY THE STATION.

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INTRODUCTION.

The following investigations were carried on in the summer of 1902. They are a continuation of some work started by Professor S. A. Beach as far back as 1892, the general object of which was to determine what varieties of grapes are self sterile and what other varieties are best to use as pollenizers for these self sterile sorts.¹ One of the first questions that comes up in such an investigation is, naturally: What causes self sterility in the grape? There are several causes which might produce this condition: (1) What is known to botanists as dichogamy, or the pistils and stamens from the same blossom and usually from the same plant maturing at different periods; (2) lack of affinity between pollen and pistil from the same plant so that even though pollen falls on the pistil fertilization does not result; (3) the pollen itself being so scanty as to render fertilization improbable if not impossible; (4) lack of viability in the pollen itself rendering it impotent not only on its own pistil but also on all others. For reasons which will be discussed in the latter part of this paper the writer considered that the first and second of these causes are not probable ones. The third seemed quite probable and the results secured by Beach and published in Bulletin No. 169 seemed to indicate that the fourth was one of the causes, if not the only cause, why certain varieties of grapes should be self sterile; as the results there showed that the pollen of self sterile grapes so far as tested was not generally potent on other self sterile sorts.

INVESTIGATION.

AMOUNT OF POLLEN.

This year observations were made on a great many different varieties of grapes as to the amount of pollen present. All of the estimates were of course approximate since pollen is a substance which it would be very difficult if not impossible to measure with any degree of exactness. These observations were made both with the naked eye and simple lens. There were great variations in the quantity of pollen present on the different blossoms, but the variations did not appear to be particularly significant.

¹ See Bulletins Nos. 157, 169 and 223 of this Station.

BULLETIN No. 224.

A STUDY OF GRAPE POLLEN.

N. O. BOOTH.

SUMMARY.

I. The self-sterility which is known to exist among many varieties of cultivated grapes is in many cases, if not all, due to a lack of potency in the pollen.

II. This lack of potency is indicated in the pollen grains by a shape which is quite different from that of potent pollen.

III. It is also shown in the arrangement of the pollen either dry or in liquid media.

IV. Certain varieties of grapes bear pollen in which both the potent and impotent forms are mixed. Trial of this mixed pollen shows that the amount which germinates is approximately in proportion to the potent forms present.

There were greater variations on different clusters of the same vine than normally appeared on different vines of different varieties. The last clusters of flowers to bloom, and sometimes the first, are usually not so well supplied with pollen as those which appear at the height of the blossoming season. Vines just coming into bearing and having only one or two clusters on the vine were usually scantily supplied with pollen. With some of the varieties, even where there was no apparent cause in the condition of the vine, the amount of pollen present was apparently insufficient to make pollination at all certain. However, with most of the self-sterile varieties the pollen was quite plentiful and apparently quite sufficient for pollinating purposes.

LABORATORY STUDY OF POLLEN.

At the same time that these observations were being made the pollen itself was being studied to determine if possible its status as a factor bearing on fertilization. This part of the work was wholly of a laboratory and microscopic nature, the only portion which took place in the field being the gathering of the blossoms. For this purpose the following varieties were selected for examination and comparison.

TABLE I.—VARIETIES OF GRAPES SELECTED FOR COMPARISON OF POLLEN.

Parentage.		Self-sterile varieties.			Self-fertile varieties.		
		No.	Variety.	Class. ¹	No.	Variety.	Class. ¹
Riparia	x	1	Clevener	4	1	Clinton	2
“	x	2	Marion	3	2	Janesville	1
“	x	3	Elvibach	4	3	Berckmans	1
Labrusca	x	4	Aminia	4	4	Agawam	2
Riparia	x	5	Grein Golden	4	5	Missouri Reisling	2
Labrusca	x	6	Barry	4	6	<i>Rogers No. 32</i>	2
“		7	Wyoming	4	7	Lucile	1
“	x	8	Black Eagle	4	8	Triumph	2
“	x	9	Massasoit	4	9	Brilliant	2
“	x	10	Roscoe	4	10	Lindmar	2
Lincecumii		11	Hexamer	4	11	Bailey	2

¹ The numbers under "Class" refer to classification given by Beach in Bulletin No. 157: Class 1 includes varieties in which sacked blossoms gave clusters varying from perfect to somewhat loose; Class 2, clusters marketable — moderately compact or loose; Class 3, clusters unmarketable; and class 4, self-sterile — no fruit developed on covered clusters.

Here we have a comparison, in each instance, of two varieties blooming at the same or nearly the same time, with similar parentage but one variety being self sterile and the other self fertile, the object being to eliminate so far as possible all differences which might be due to species or strain. These investigations were along the two general lines: (1) Trial of the pollen in sugar solution to see if it would germinate; (2) examination of the pollen under a microscope to see if there were any constant morphological differences between that of the self-sterile and self-fertile varieties.

CULTURES.

In 1 per ct. sugar solution.—The results from the first four kinds of pollen tested were uncertain. This was due to using a sugar solution which was too weak for this kind of pollen to make a good growth (1 per ct.). The only difference shown in this pollen was in the budding, which is the first stage in pollen germination. See Fig. 1. None germinated. The Clinton and Janesville both showed buds on from 5 to 10 per ct. of the grains, but the Clevenor and Marion showed at the end of four days no change from their condition at time when placed in solution.

In 2 1-2 per ct. sugar solution.—On June 18 pollen grains of Elvibach, Berckmans, Aminia and Agawam were placed in hanging drops of $2\frac{1}{2}$ per ct. sugar solution. They were examined for three successive days thereafter and the number of germinations noted. The Elvibach and Aminia pollen did not germinate or even bud. About 4 per ct. of the Berckmans germinated and about 10 per ct. of the Agawam.

In 5 per ct. dextrose solution.—On June 21 pollen was prepared as before, using a 5 per ct. solution of dextrose in place of the previous medium. The varieties from which pollen was taken in this instance were Grein Golden, Missouri Reisling, Barry, Rogers No. 32, Wyoming and Lucile. Notes were taken on these cultures on June 23, at which time they were in the height of their growth, none germinating after that date. At this time the pollen grains of the Grein Golden, Barry and Wyoming had not changed in any way from their condition when they were first placed in the solution. About 12 per ct. of the Missouri

Reisling germinated, 20 per ct. of *Rogers No. 32* and 10 per ct. of the Lucile.

In 10 per ct. dextrose solution.—Pollen of these same varieties was placed at this latter date in 10 per ct. dextrose solution with the following results: Out of an estimated 200 grains of pollen of Grein Golden, one made a very weak growth; Barry and Wyoming pollen grains not changed in any way; Missouri Reisling, about 15 per ct. germinated; *Rogers No. 32*, about 50 per ct. (especially strong); Lucile was accidentally destroyed.

In 10 per ct. sugar solution.—The same varieties were tried in 10 per ct. sugar solution with the following details: Of Grein Golden, out of an estimated 150 grains one germinated, growth short and weak; Missouri Reisling, 20 per ct. grew; Barry none; *Rogers No. 32*, about 75 per ct. good and strong; Lucile, at least 80 per ct., a mass of growth.

In 20 per ct. sugar solution.—In 20 per ct. sugar, Grein Golden shows 2 in approximately 250; Missouri Reisling 25 per ct., Barry none, *Rogers No. 32* 90 per ct., Wyoming about 5 per ct. (growth weak), Lucile 95 per ct.

On July 2 cultures were made in 20 per ct. sugar solution with pollen of Black Eagle, Triumph, Massasoit, Brilliant, Roscoe, Lindmar, Hexamer and Bailey. Notes taken the following day show: Black Eagle, none budded or grown; Triumph, practically all budded, but only about 10 per ct. grown to any length; Massasoit, little budding and no growth; Brilliant all budded, 60 per ct. grown; Roscoe, none budded and none grown; Lindmar about 60 per ct. budded and 10 per ct. grown; Hexamer, no buds and no growth; Bailey, about 60 per ct. budded and 5 per ct. grown. The foregoing results are tabulated below:

TABLE II.—GERMINATION OF POLLEN GRAINS IN CULTURES.

Name of variety.	Class.	Fertility or sterility as determined by previous field experiments.	Date when placed in solution.	Date when examined.	Solution used for germination.	Percentage of germinations.
					<i>Per ct.</i>	<i>Per ct.</i>
Elvibach	4	Sterile	June 18	June 19	2½ sugar	0
Berckmans	1	Fertile	"	"	" "	4
Aminia	4	Sterile	"	"	" "	0
Agawam	2	Fertile	"	"	" "	10
Grein Golden	4	Sterile	June 21	June 23	20 "	1, weak
Mo. Reisling	2	Fertile	"	"	" "	25
Barry	4	Sterile	"	"	" "	0
Rogers No. 32	2	Fertile	"	"	" "	90
Wyoming	4	Sterile	"	"	" "	5
Lucile	1	Fertile	"	"	" "	95 very strong
Black Eagle	4	Sterile	July 3	July 5	" "	0
Triumph	2	Fertile	"	"	" "	10
Massasoit	4	Sterile	"	"	" "	0
Brilliant	2	Fertile	"	"	" "	60
Roscoe	4	Sterile	"	"	" "	0
Lindmar	2	Fertile	"	"	" "	10
Hexamer	4	Sterile	"	"	" "	0
Bailey	2	Fertile	"	"	" "	5

MICROSCOPIC EXAMINATION.

Besides these there is another difference between the self sterile and the self-fertile pollen which is noticed on microscopic examination and which seems to be constant. The self-fertile grains seem to be surrounded by a mucilaginous substance which makes them stick to one another more or less so that the pollen whether it lies dry on the slide or is placed in liquid media arranges itself in a succession of clumps. This mucilaginous substance does not appear to be soluble in water as the pollen grains retain their respective positions even after several days in the solutions. The self-sterile pollen, on the other hand, shows no such arrangement but the grains distribute themselves either on the slide or in the liquid like so much dry powder, quite by chance.

The next phase of the work was the microscopical examination of the dry pollen grains to see if there were any characteristic differences in the size or shape of the different classes of pollen. All pollen, whatever its shape may be when it comes from the anther, swells on contact with water and most other liquids, as-

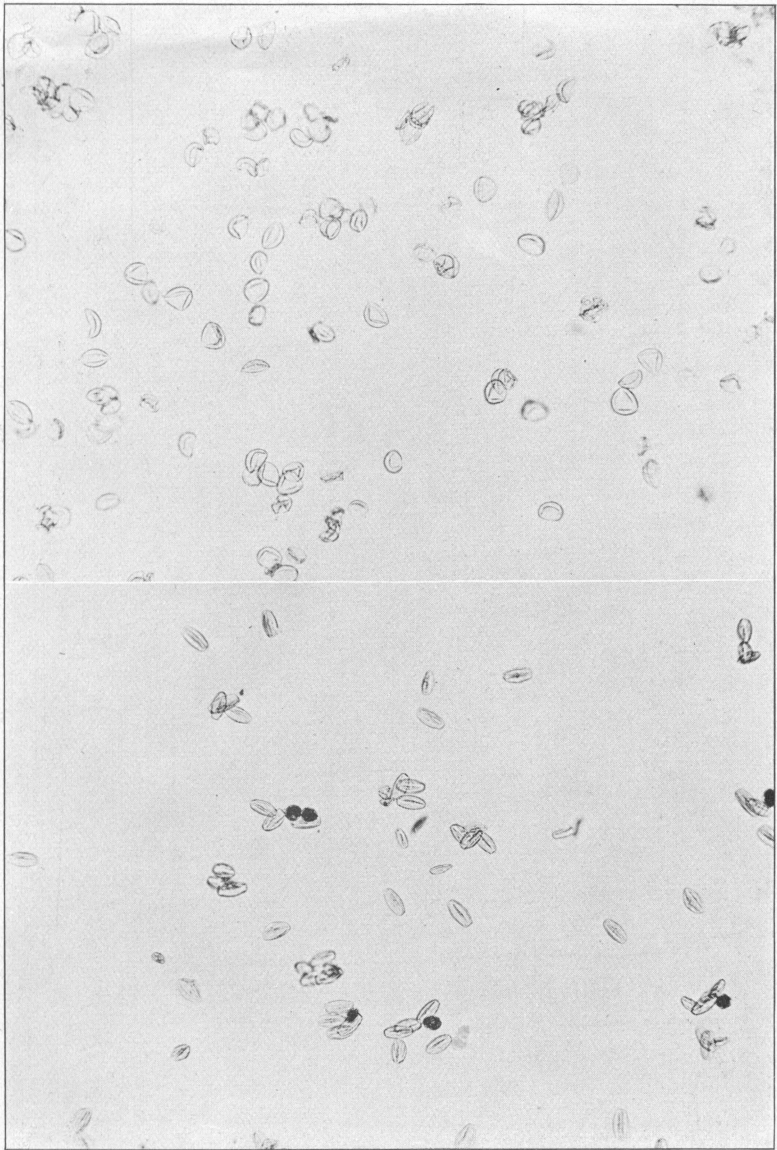


PLATE I.—GRAPE POLLEN:

UPPER.—GREIN GOLDEN, SELF-STERILE, CLASS 4.

LOWER.—MISSOURI RIESLING, SELF-FERTILE, CLASS 2.

(For classification see footnote to table I.)

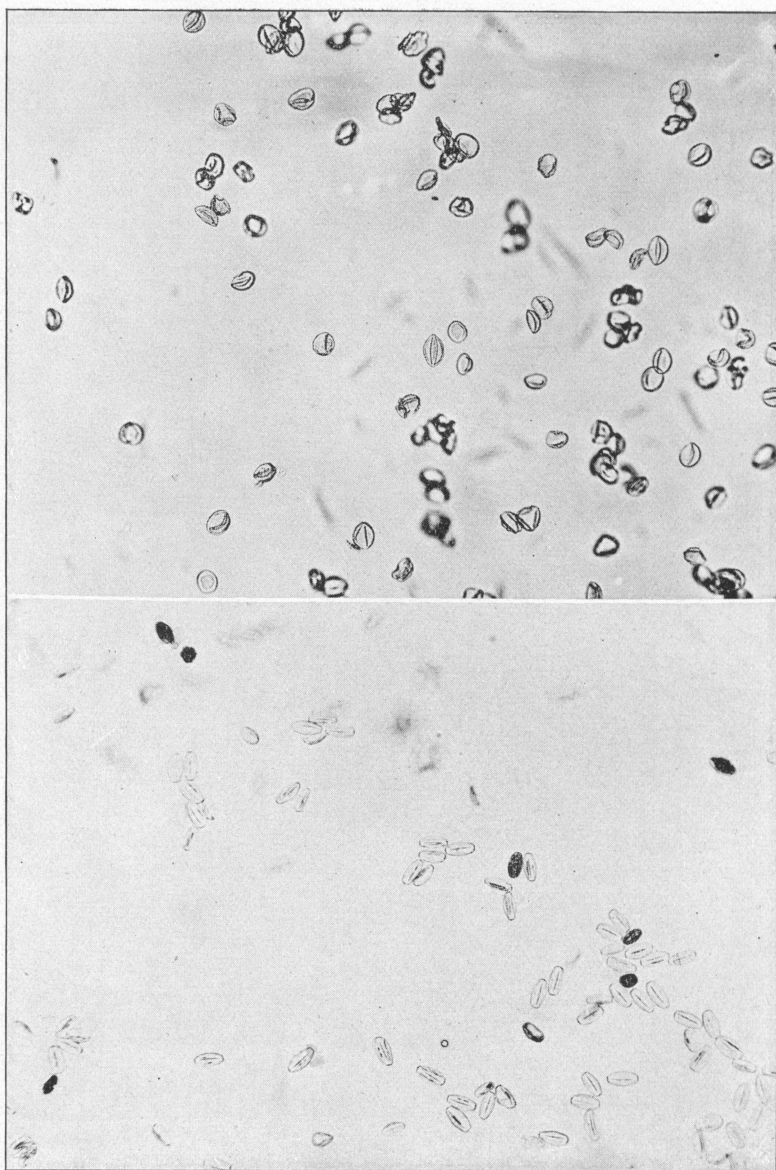
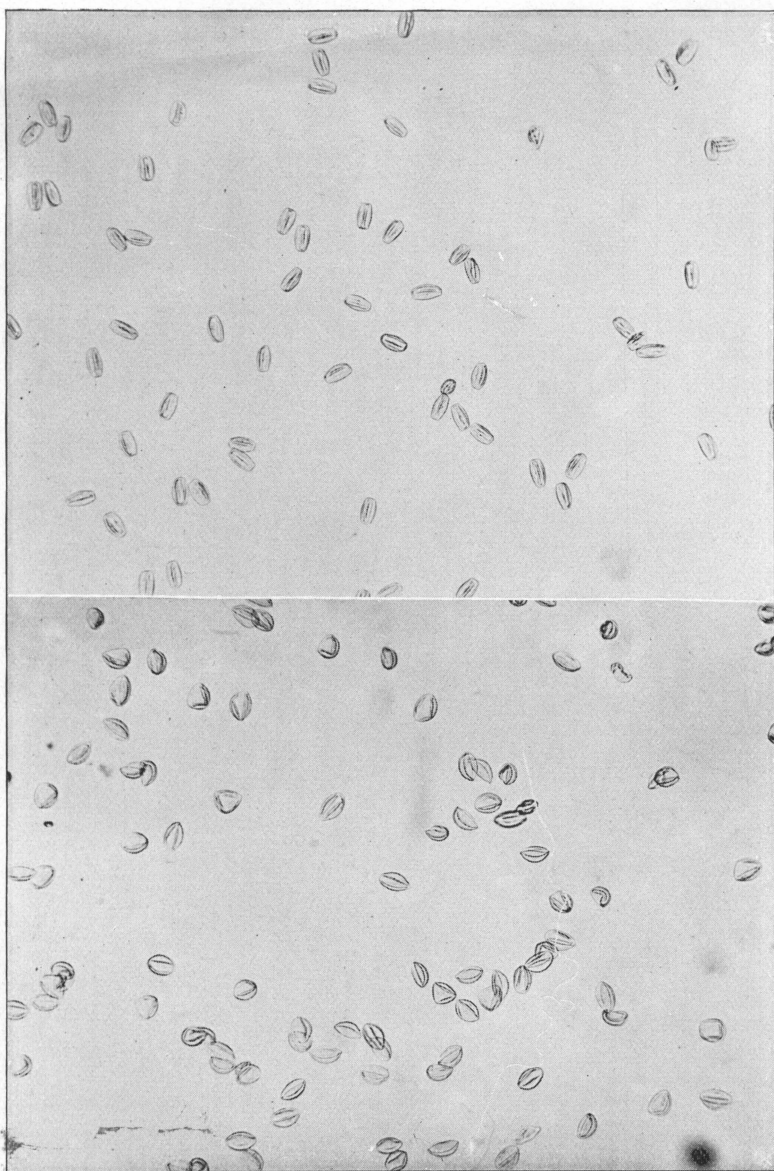


PLATE II.—GRAPE POLLEN:
UPPER.—BARRY, SELF-STERILE, CLASS 4.
LOWER.—ROGERS NO. 32, SELF-FERTILE, CLASS 2.
(For classification see footnote to table I.)



Lower
 Upper

PLATE III.—GRAPE POLLEN:
 UPPER.—BLACK EAGLE, SELF-STERILE, CLASS 4.
 LOWER.—TRIUMPH, SELF-FERTILE, CLASS 2.
 (For classification see footnote to table I.)

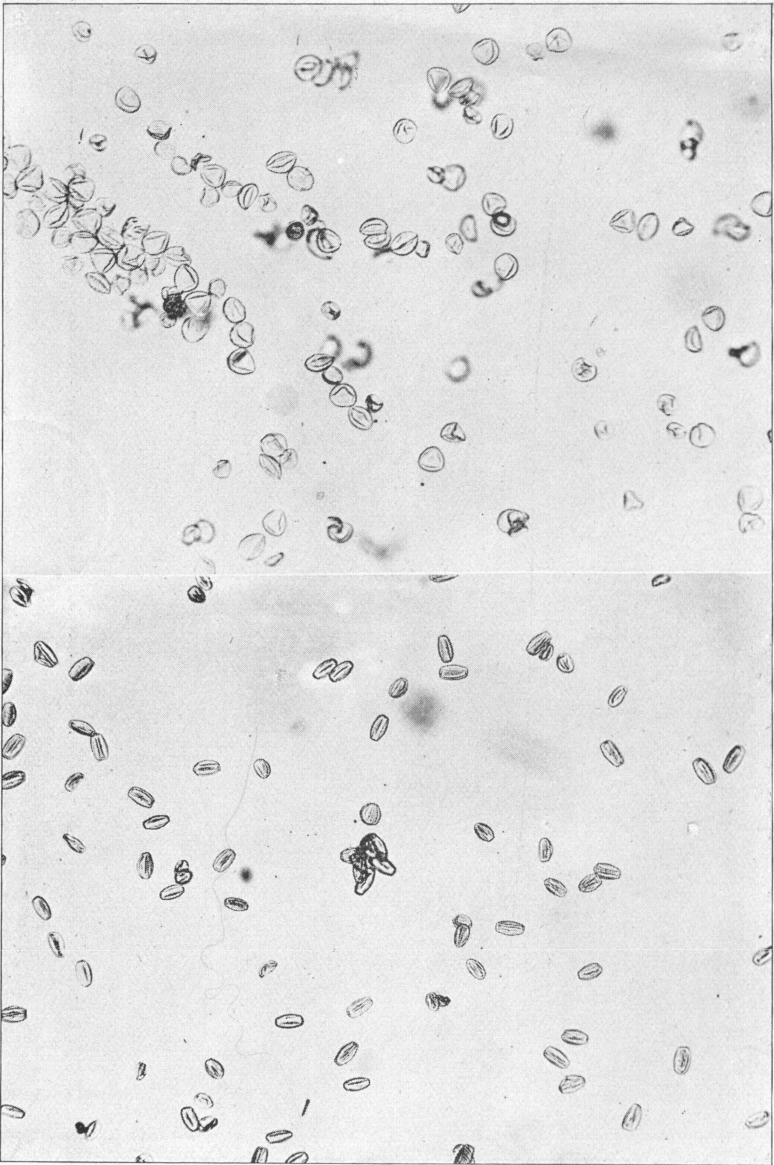


PLATE IV.—GRAPE POLLEN:
UPPER.—WYOMING, SELF-STERILE, CLASS 4.
LOWER.—LUCILE, SELF-FERTILE, CLASS 1.
(For classification see footnote to table I.)

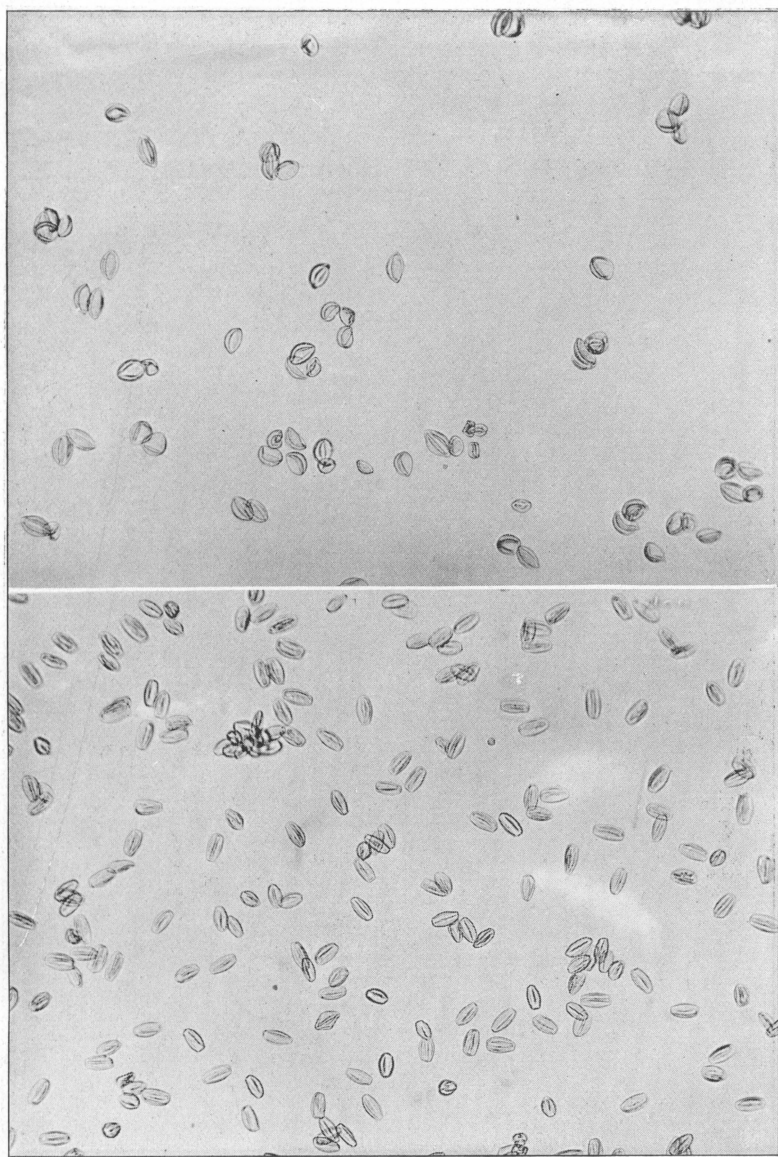


PLATE V.—GRAPE POLLEN:
UPPER.—MASSASOIT, SELF-STERILE, CLASS 4.
LOWER.—BRILLIANT, SELF-FERTILE, CLASS I.
(For classification see footnote to table I.)

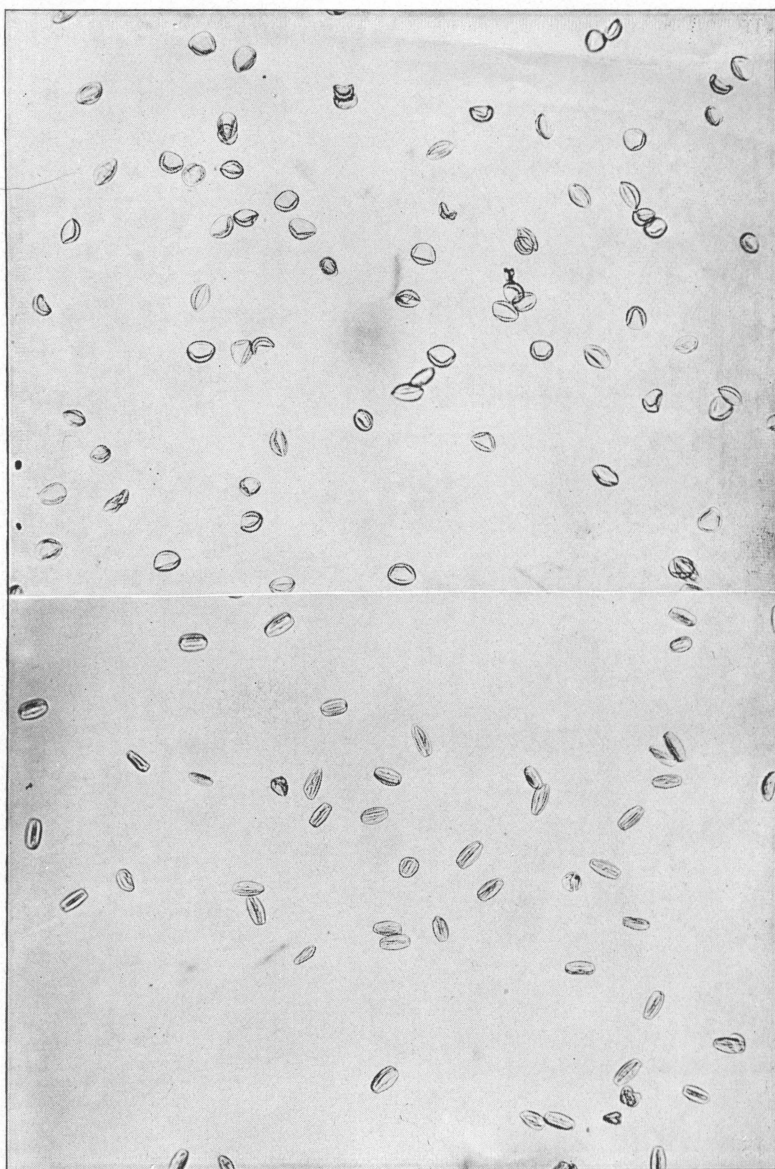


PLATE VI.—GRAPE POLLEN:
UPPER.—HEXAMER, SELF-STERILE, CLASS 4.
LOWER.—BAILEY, SELF-FERTILE, CLASS 2.
(For classification see footnote to table I.)

suming an approximately spherical shape. Consequently these studies had to be made with the dry pollen. The results of this part of the work can be better illustrated than told. On the preceding pages are cuts which are reproduced from photo-micrographs of the pollen mounted in balsam. The characteristic differences are very apparent. The self-fertile forms are oblong, blunt at the ends and quite symmetrical. The self-sterile sorts, as may be seen, are quite different in shape, being more irregular and usually more pointed than those of the other class. Pollen from all other varieties in the list previously given showed these same shapes according to the class to which the variety in question belonged, but the blooming season of the first eight varieties was past before I thought of illustrating this phase of the work, and later the balsam mounts of Roscoe and Lindmar were accidentally destroyed so that illustrations of these cannot now be presented.

Examination of pollen from varieties of grapes which had given conflicting results in Prof. Beach's work to determine if they were

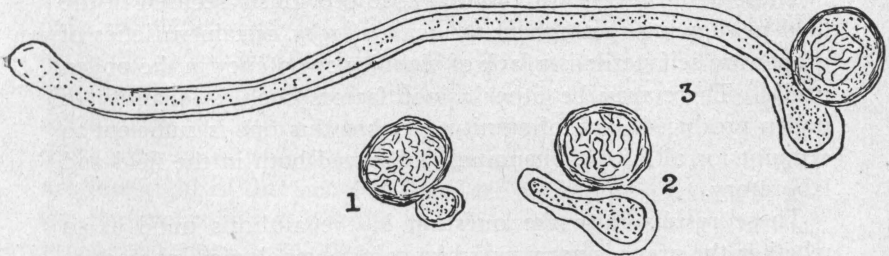


FIG. 1.—GRAPE POLLEN AT DIFFERENT STAGES OF GROWTH.

1, A GRAIN WHICH HAS JUST BUDDED; 2 AND 3, MORE ADVANCED STAGES OF GROWTH.

self sterile showed that the self-sterile and the self-fertile forms may be mixed in the same variety. Eaton was the first one of these varieties which was examined on June 26. The pollen of this variety is quite irregular in shape and size and only about 10 per ct. show the regular self-fertile shape, although there are numerous others which approach it very closely. Its grains are considerably larger than those of average pollen. In 20 per ct. sugar solution about 15 per ct. of this pollen germinated. None of the growths appeared healthy however or at least were not like

those of completely self-fertile pollen. In normal self-fertile pollen the tubes formed on germination are approximately the same size throughout, but the tubes of Eaton varied in size at different points of their course, being restricted at one place and swollen and distorted at another. The tubes were fully as long as those of normal self-fertile pollen. Other varieties which Prof. Beach has determined as belonging to the same doubtful class are Dracut Amber, Maxatawney, Faith, Geneva, Montefiore, Canonicus, Oneida, Gold Dust and White Jewell. Pollen of these was tested as was also that of Red Trauminer, Red Veltliner and Chables sent by Dr. Tinker of Ohio. In each instance the percentage of pollen which germinated did not vary widely from the percentage of self-fertile forms which the microscope showed that particular variety to contain. And it appears very certain that the capacity of the pollen for growth is in direct proportion to the number of self-fertile forms present and their conformity to the self-fertile type. Pollen of the different varieties of grapes varies considerably in size, but there is no apparent connection between the size and the germinating capacity.

These results seem to confirm those previously secured in the field in showing that one of the reasons why certain varieties of grapes are self sterile is a lack of viability or potency in the pollen itself.¹ There may be other minor factors such as quantity of pollen produced, lack of affinity, etc. but this one is sufficient to account for all of the phenomena observed both in the field and laboratory.

These results raise the question in the author's mind as to whether the grape is not now, so far as its phænological characters are concerned, in a state of evolution from an older hermaphrodite form to forms that are essentially staminate and pistillate. All of the staminate flowers, so called, which I have observed have small abortive pistils; which also conforms with the observations of Engelman.² Others report staminate flowers with no trace of

¹ Such plants are well known and are called by botanists pseudo-hermaphrodites. I am not aware, however, that any of our cultivated plants have been heretofore recognized as belonging to this class. See Natural History of Plants, by Kerner, page 291.

² Bushberg Catalogue, page 7. (Edition of '95.)

pistil remaining. On the other hand the most advanced pistillate forms still retain their stamens although so far as their true function is concerned they are apparently abortive. There is considerable corroborative evidence that this incomplete evolution has taken place. The whole path is marked by transitional forms; thus there are no distinct classes of self-sterile and self-fertile grapes but all gradations exist from one extreme to the other.¹ This blending is quite apparent from an examination of pollen from a dozen or two of varieties selected by chance. In selecting the varieties which are given in the list in the early part of this bulletin extreme types were chosen purposely so that any difference which might exist would be most apparent. It further appears that pollen from the same variety may vary slightly in different years and even the same year in different localities.² These facts seem to show that our grape is in a state of very unstable equilibrium, coming from an ancestry of diverse sexual types.³

It might be interesting to consider the probable cause of this evolution. It seems reasonable to suppose that there must be some advantage which the staminate and pistillate vines have over the assumedly older hermaphrodite forms, or they would not have developed and persisted. This advantage is supposed to lie in the fact that cross fertilization is thus assured. The seedlings resulting from cross fertilization being usually the stronger⁴ would have the better chance in the struggle for existence with those from vines which were self fertilized. However we should not lose sight of the fact that there are also some advantages to the hermaphrodite forms and the chief one of these lies in the greater certainty of fertilization and consequent seed production. Thus where vines are widely scattered the hermaphrodites would have the advantage since the chances of cross fertilization of the

¹ See Bul. No. 157:424 et. seq.

² Beach, Bul. No. 157:424. Bushberg Catalogue, page 8. There is a vine on this station which bears both staminate and hermaphrodite flowers. Mr. N. B. White, Norwood, Mass., reports that he has a male (?) Rip. X Lab. vine which has fruited twice in the last thirty years, the pistils evidently varying in strength but being generally too weak to produce fruit.

³ Natural History of Plants, page 300.

⁴ Cross and Self-Fertilization in the Vegetable Kingdom. Darwin.

staminate and pistillate forms would be remote. Where the conditions are such that vines are numerous and closely adjacent the opposite would be the case as fertilization of the pistillate flowers would be comparatively certain and the seedlings resulting would have the advantage over those resulting from self-fertilized hermaphrodites. It must be remembered that the adjacency referred to is not merely a matter of distance but would be modified more or less by other factors such as number and kind of insects normally present, direction of winds, surrounding vegetation, etc. It must also be remembered that although pistillate flowers are necessarily cross-fertilized it does not follow that hermaphrodite flowers are necessarily self-fertilized. These may be cross fertilized also either by other hermaphrodites or by staminate, and the pistillate forms may be pollinated by either the staminate or hermaphrodites. In any of these cases the resulting seedling, while it would possess the individual vigor due to crossing, might be itself in any class so far as its phænological characters are concerned. This mixing and the fact that the advantages of each class tend to a certain extent to balance each other probably accounts for it that neither form has supplanted the other but both are still present. In reference to the question referred to in the first part of this bulletin as to whether dichogamy or the maturing of stamens and pistils on the same plant at different periods might exist in the grape, observations seem to show that this does not exist. The anthers usually burst and the pollen is liberated before the stigmas become receptive but a good portion of the pollen remains on the anther and is gradually released even some time after the pistils are in condition to be fertilized. Grape pollen is notably resistant to the ordinary influences of decay,¹ and it can be readily seen how in an inconspicuously flowered plant like the grape, where insect visits might not be so numerous as would be desired for pollinating purposes, keeping qualities on the part of the pollen grains would be so valuable a factor that it could not be sacrificed even for so important a consideration as cross fertilization. The question as to whether

¹ Bul. No. 157, page 438. Pollen was germinated at this Station this year three weeks after it had been gathered in California.

there may not be a lack of affinity between the pollen of a self sterile grape and its own pistil will be difficult to settle conclusively, and yet the foregoing evidence seems to show that such lack of affinity does not exist, since poor pollen was found in all those varieties examined of the self-sterile class, and only in those of this class. Furthermore the phænological evolution referred to, if this be accepted as a fact, is strong negative proof that lack of affinity does not exist, for if any of the original hermaphrodite forms had possessed that quality by which pollen of a certain plant is impotent on the pistils of the same plant at the same time being good on all others then there would have been no cause to produce the staminate and pistillate forms of today, for cross fertilization would have already been assured.

The economic bearing of these results is quite apparent. It has heretofore been necessary in order to determine whether a certain variety of grape was self fertile or not to sack certain clusters before the blossoms opened and see if any fruit set with the pistils thus protected from the entrance of outside pollen. These operations, besides taking considerable time, are subject to all the accidents which are apt to occur when such delicate work is being done in the field. The pressure of the sack may destroy the pistil or the sack itself may be knocked off by persons or storms and there is always the possibility of the accidental entrance of other pollen. In careful experiments all this is provided for by duplicating the sacks until the chances are very small of such accidents vitiating the results. But all this adds to the work, whereas by the use of the microscope the sexual status of a variety may be determined in a few minutes so far as that season is concerned. The older cultivated varieties in the east have nearly all been determined but there are still some of these which are doubtful and the new varieties as they are originated can be determined the first season they blossom.

It is not unreasonable to expect that observations as to the quantity and condition of the various kinds of pollen will give us better rules for the selection of fertilizers than we have at present. It may at times be of use to determine a certain variety; to illustrate, Lucile and Wyoming closely resemble each other in

fruit and in certain other characters but they may be distinguished by the fact that one has self-fertile pollen and the other self sterile.

To the hybridist this work may be of some interest since it will indicate at once all possible male parents.

It is intended to continue this work next season and it is hoped to have some further data to report.

